TETRA TECH

Preliminary Healthy Watershed Assessment (PHWA) in the Chesapeake Bay Watershed

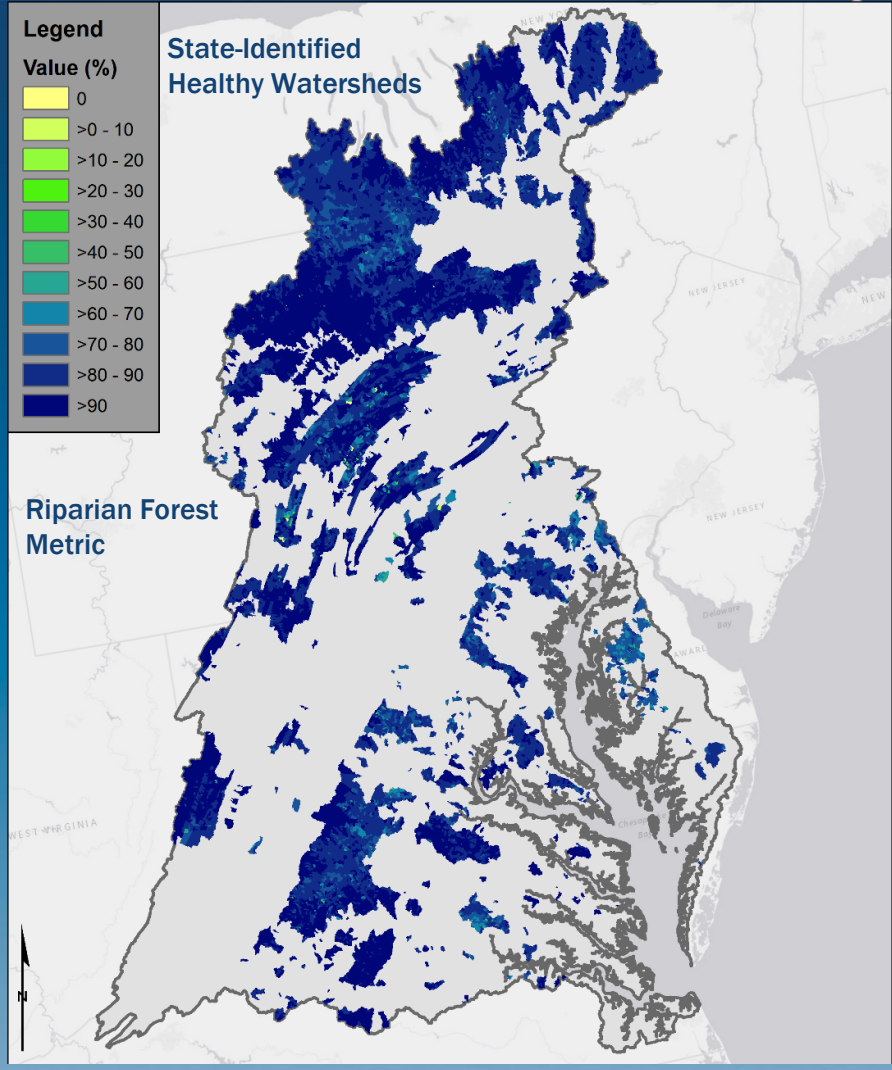
Tetra Tech Team:

Nancy Roth

Christopher Wharton

Sam Sarkar

Brian Pickard



Healthy Watersheds Goal Implementation Team Meeting June 2019

Background

- Chesapeake Bay Program (CBP) Healthy Watersheds Goal Implementation Team identified need for quantitative indicators to support watershed assessment and management
- U.S. Environmental Protection Agency (EPA) Preliminary Healthy Watershed Assessment (PHWA) as framework

Project Overview

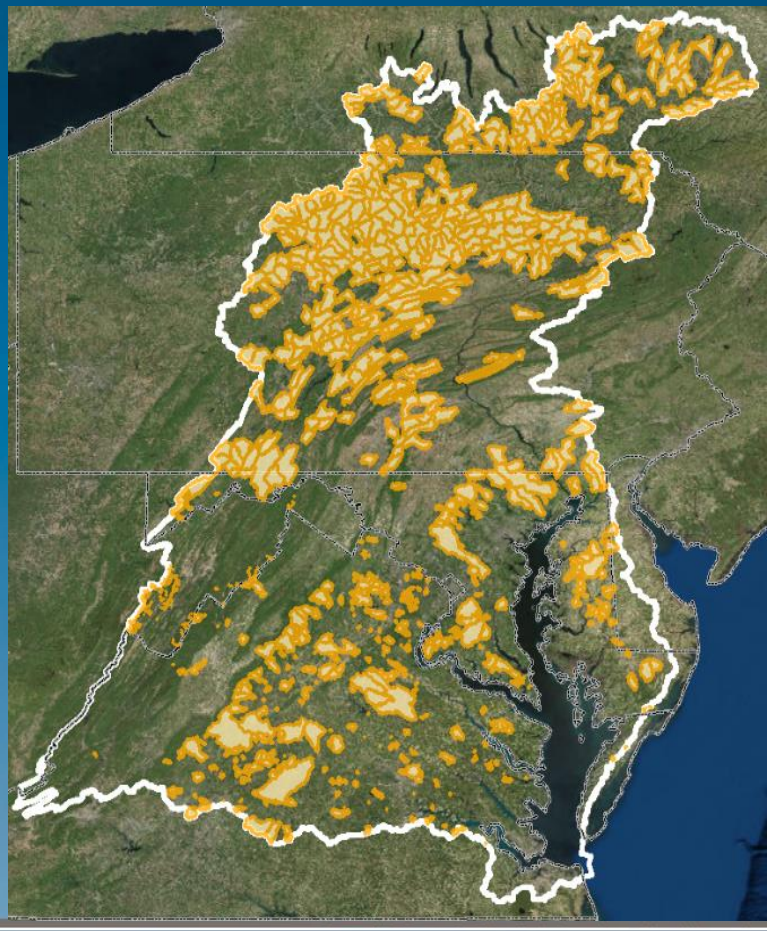
- **Apply and adapt EPA's Preliminary Healthy Watersheds Assessment framework to**
  - Assess current condition of state-identified Healthy Watersheds
  - Develop an approach for future tracking of condition
  - Assess vulnerabilities of these watersheds
- **Provide data that will help inform watershed management activities that best support the maintenance of watershed health**

Management Goals and Outcome

Goal: Sustain state-identified healthy waters and watersheds recognized for their high quality and/or high ecological value

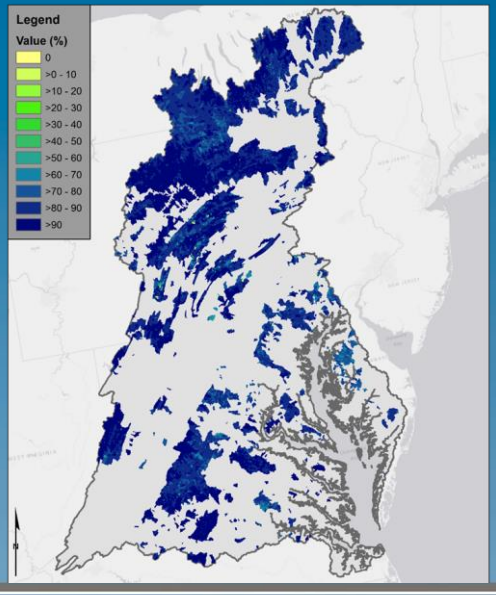
Target Outcome: 100 percent of state-identified currently healthy waters and watersheds remain healthy

- CBP Healthy Watersheds Outcome Management Strategy, 2018



Today's Presentation

- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data



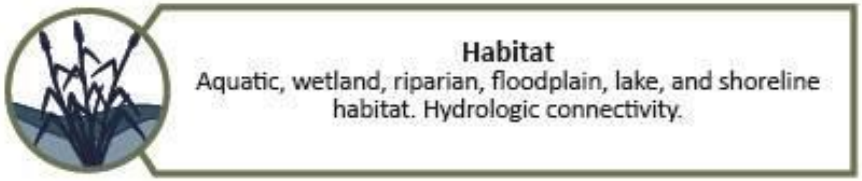
Today's Presentation

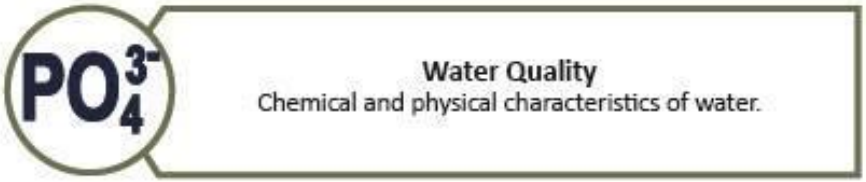
- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

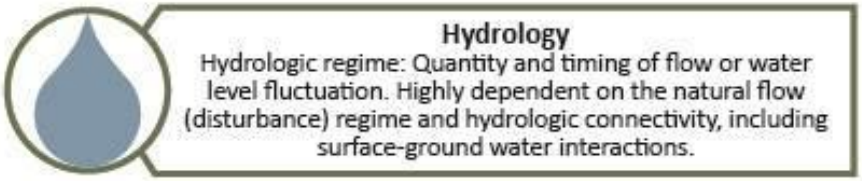
Assessing Watershed Health

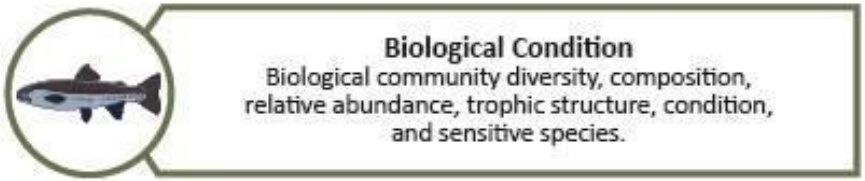
PHWA employs metrics in six categories:

- Landscape condition
- Habitat
- Hydrology
- Geomorphology
- Water quality
- Biological condition



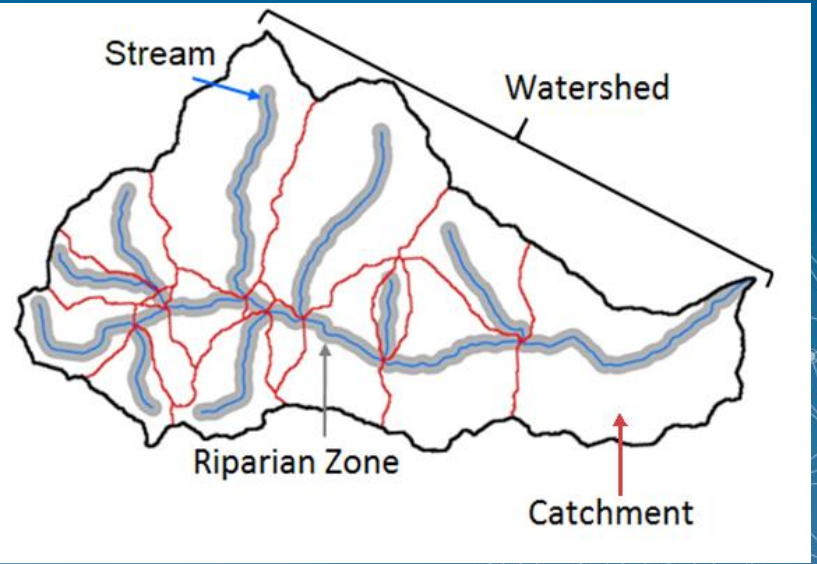






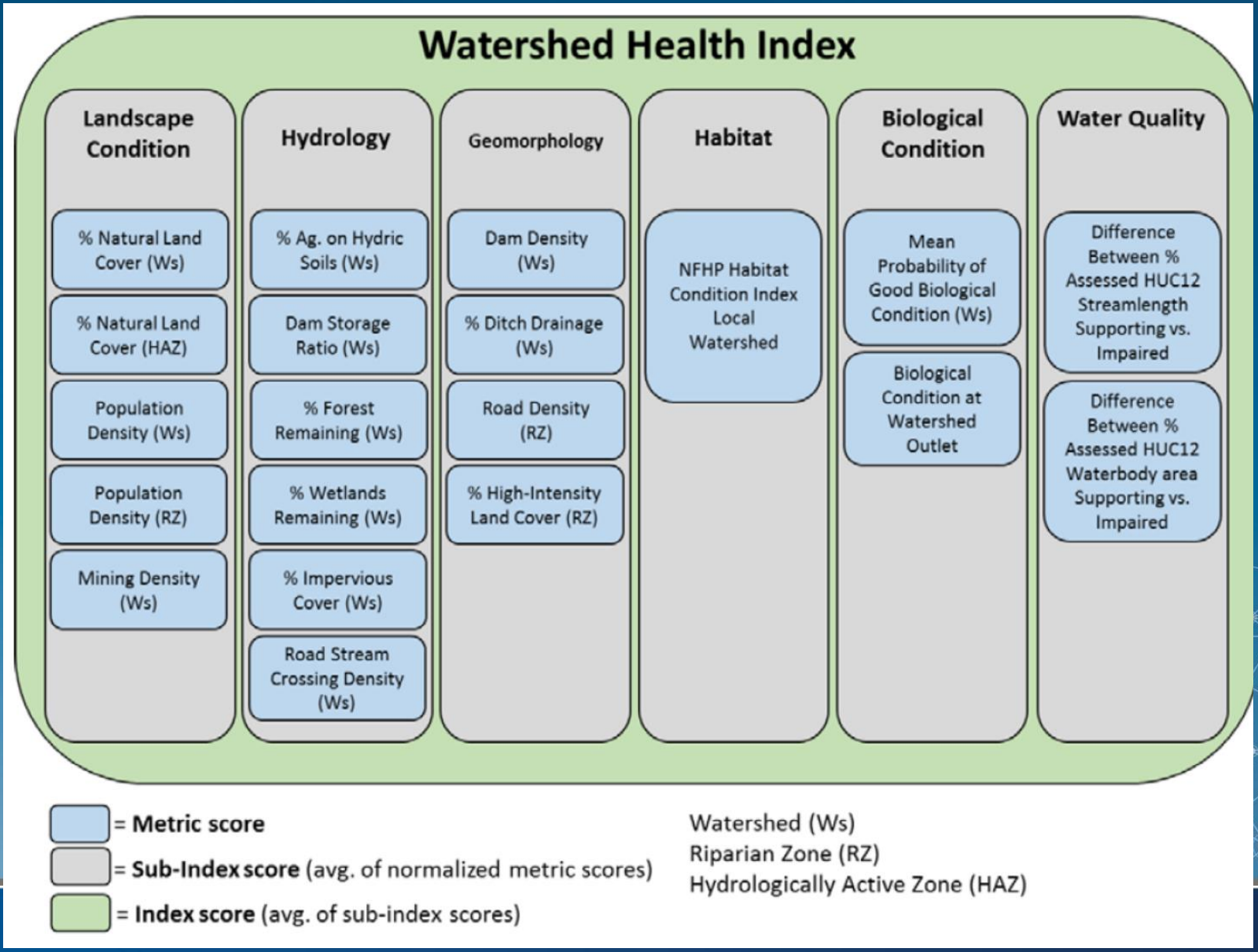
Healthy Watersheds: Catchment- and Watershed-Scale Metrics

- "Catchment" - Local catchment condition
- "Watershed" - Cumulative condition over entire watershed upstream of outlet
- Most Chesapeake Bay candidate metrics were calculated as watershed-scale metrics, reflecting influence of entire upstream watershed
  - Ex: Percent Impervious Cover in Watershed
- A few at catchment scale only
  - Ex: Aquatic Biological Condition at Outlet
- Some for riparian zone only: the corridor of land within 100 meters of stream



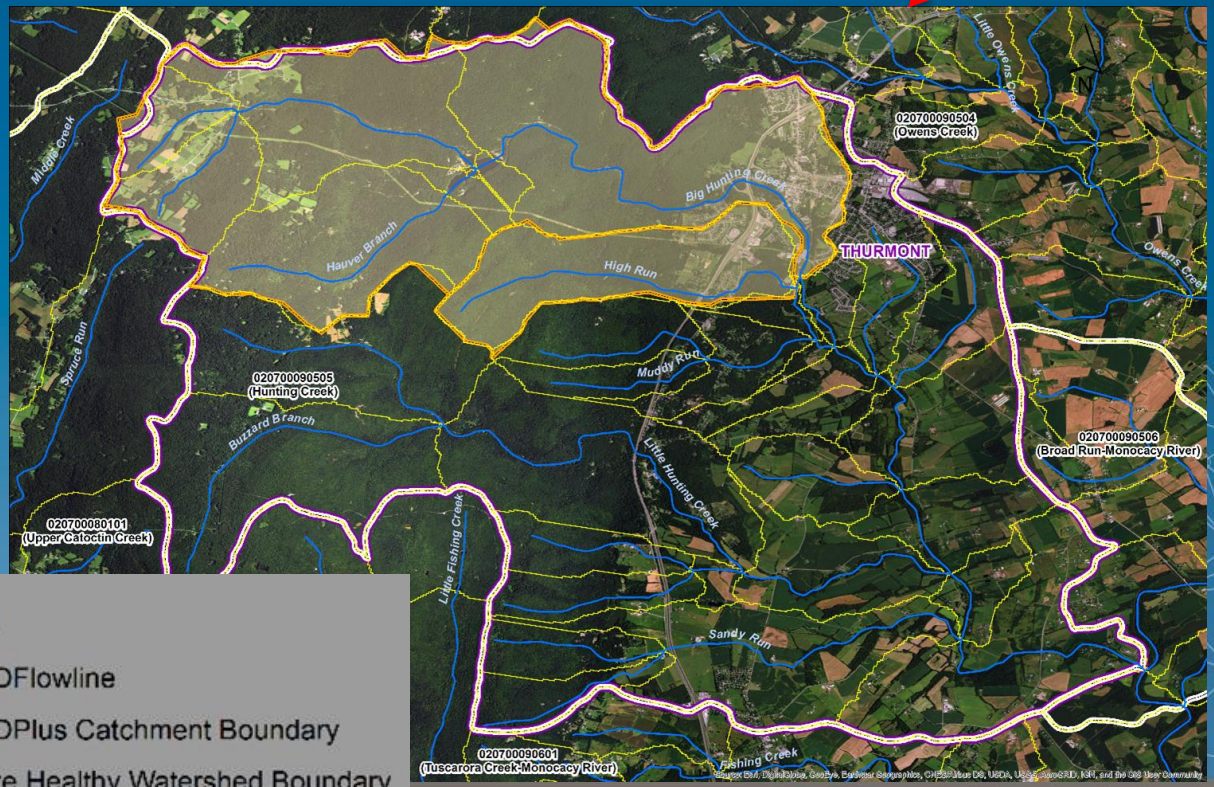
Modified from EPA StreamCat

PHWA Metrics – Watershed Health



Addressing Watershed Scale

- PHWA developed nationally to provide data at HUC12 scale; this regional application required finer scale
- Developed metrics at NHDPlus catchment scale
- Calculated for all 83,623 catchments in Chesapeake watershed (average area ~2 km^2)



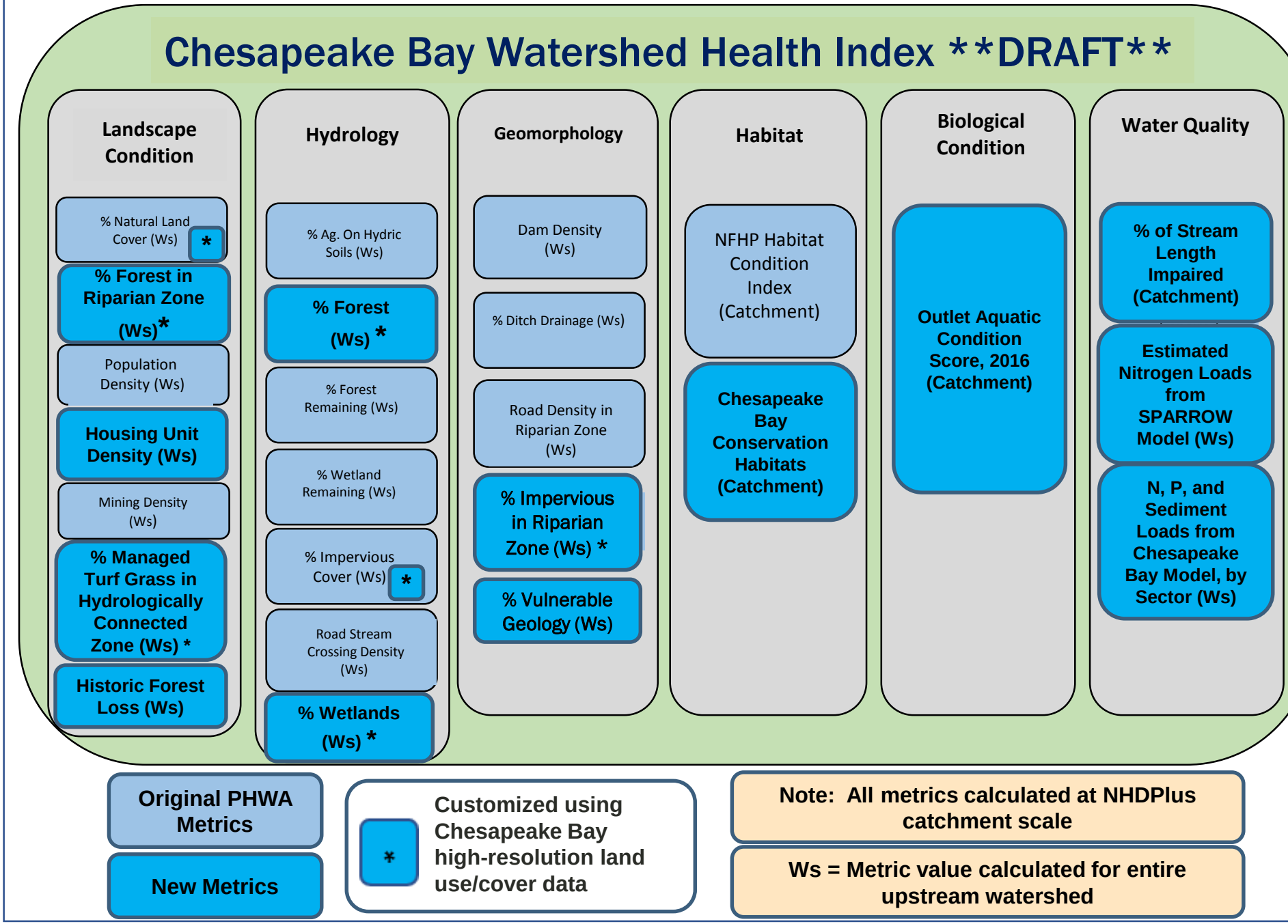
Legend

- NHDFlowline
- NHDPlus Catchment Boundary
- State Healthy Watershed Boundary
- HUC-12 Boundary

Today's Presentation

- Adapting the PHWA approach and addressing scale
- **Indicators of watershed condition**
- Indicators of watershed vulnerability
- Data visualization and access to data

Chesapeake Bay Watershed Health Index **DRAFT**



Original PHWA Metrics

New Metrics

* Customized using Chesapeake Bay high-resolution land use/cover data

Note: All metrics calculated at NHDPlus catchment scale

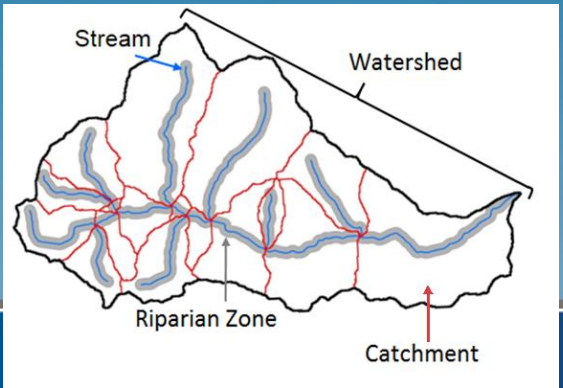
Ws = Metric value calculated for entire upstream watershed

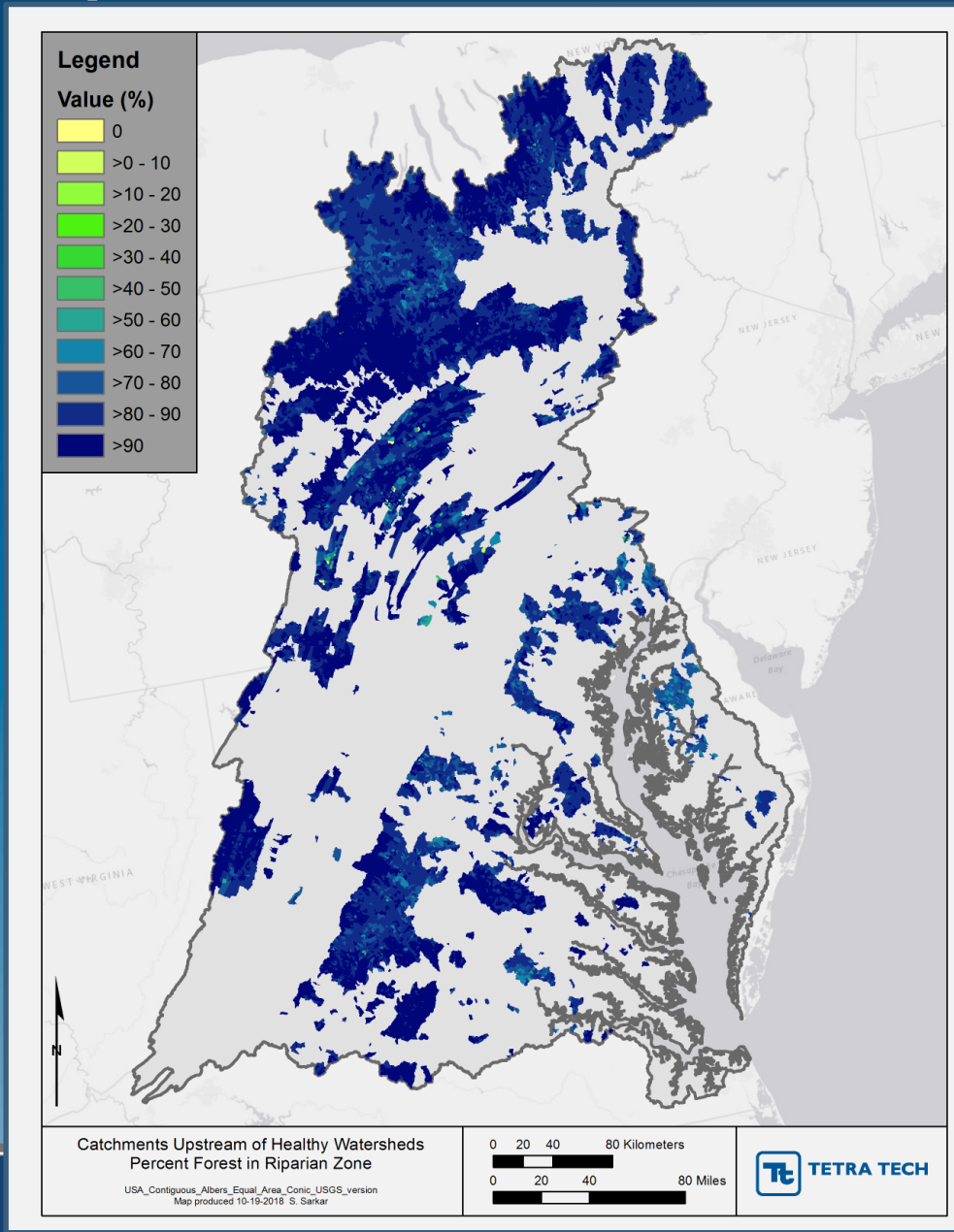
Data Sources

- For use Bay-wide, sought data that would provide consistent, wall-to-wall coverage
- Needed data at catchment or finer-scale resolution
- Derived several key indicators from recent high-resolution Chesapeake Bay land use/land cover data developed by CBP and partners
- Where possible, leveraged other geospatial data from regional sources, for example:
  - EPA StreamCat
  - National Fish Habitat Partnership
  - Chesapeake Bay model for nutrient loads
  - North Atlantic Landscape Conservation Cooperative
  - LandScope/Nature's Network

Metric Performance Example

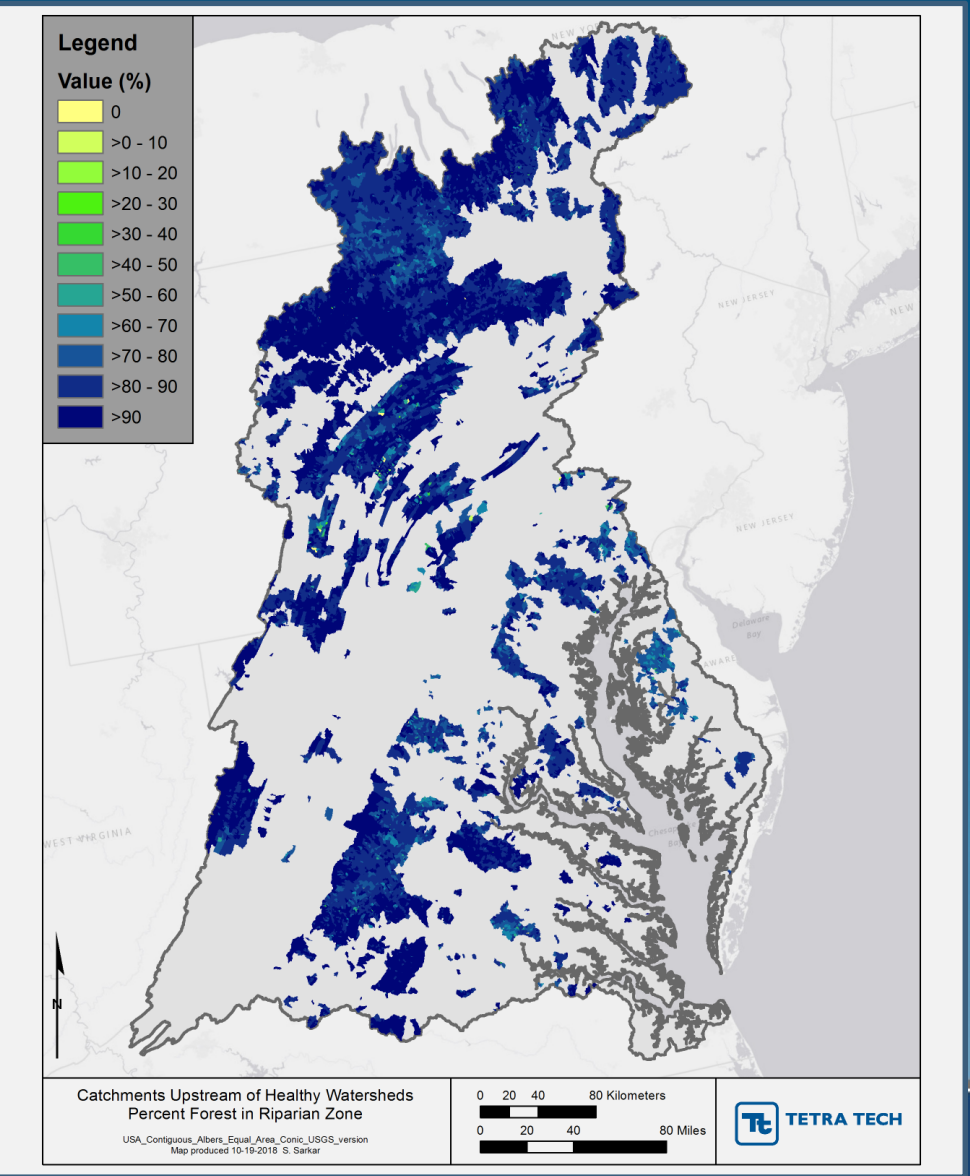
- Example: Percent Forest in Riparian Zone
- Indicative of: Landscape condition
- Value calculated for riparian zone in entire upstream watershed
- Metric expected to be high in healthy watersheds

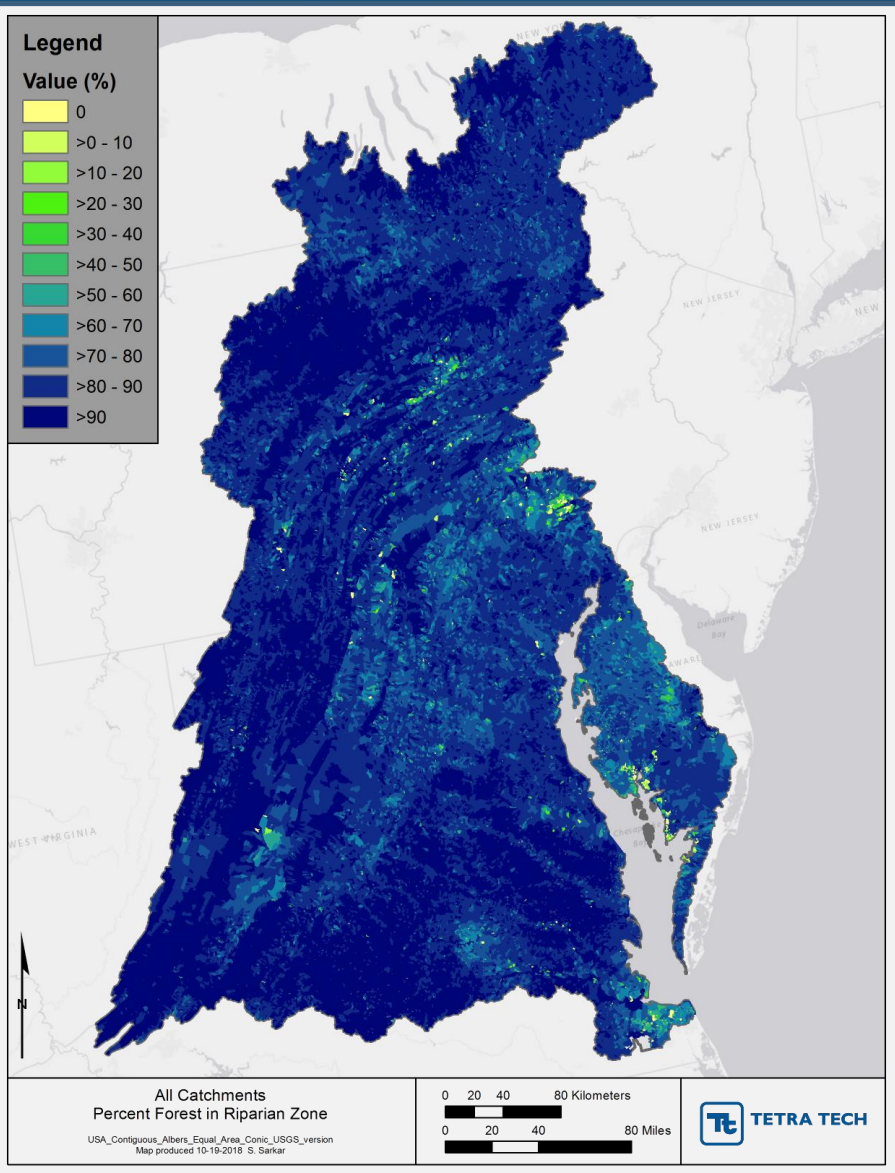




Metric Performance

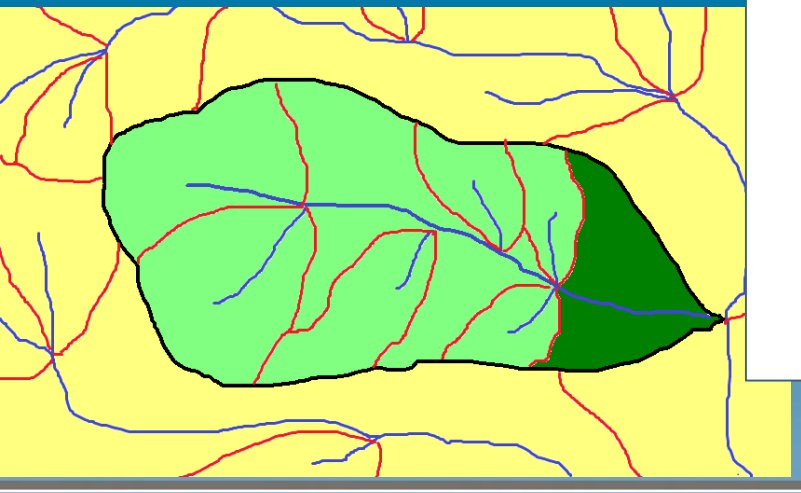
- Example: Percent Forest in Riparian Zone





Evaluating Metric Performance

- Appropriateness of data scale and completeness
- Distributions of scores for healthy watersheds
- Comparison with distribution of scores for areas outside of healthy watersheds

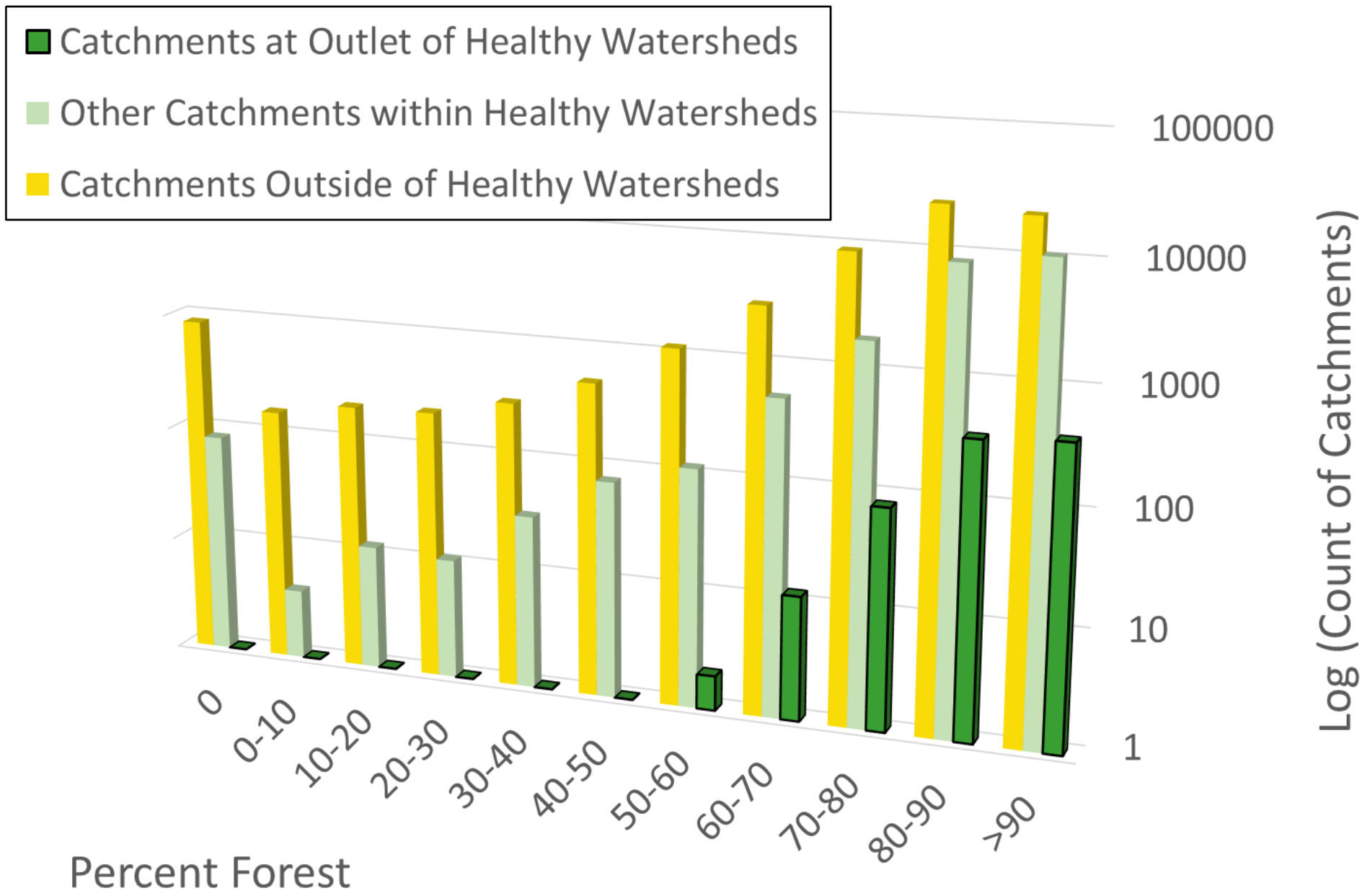


Catchments at Outlet of Healthy Watersheds

Other Catchments Within Healthy Watersheds

Catchments Outside of Healthy Watersheds

Percent Forest in Riparian Zone

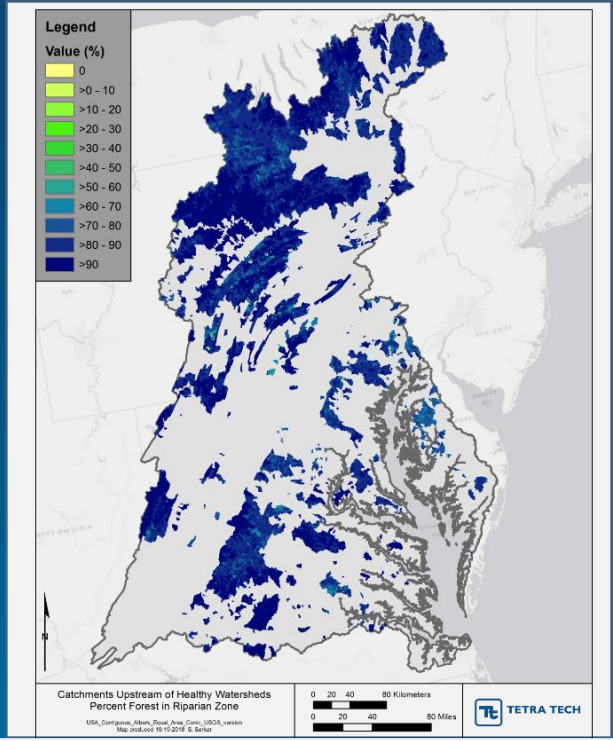


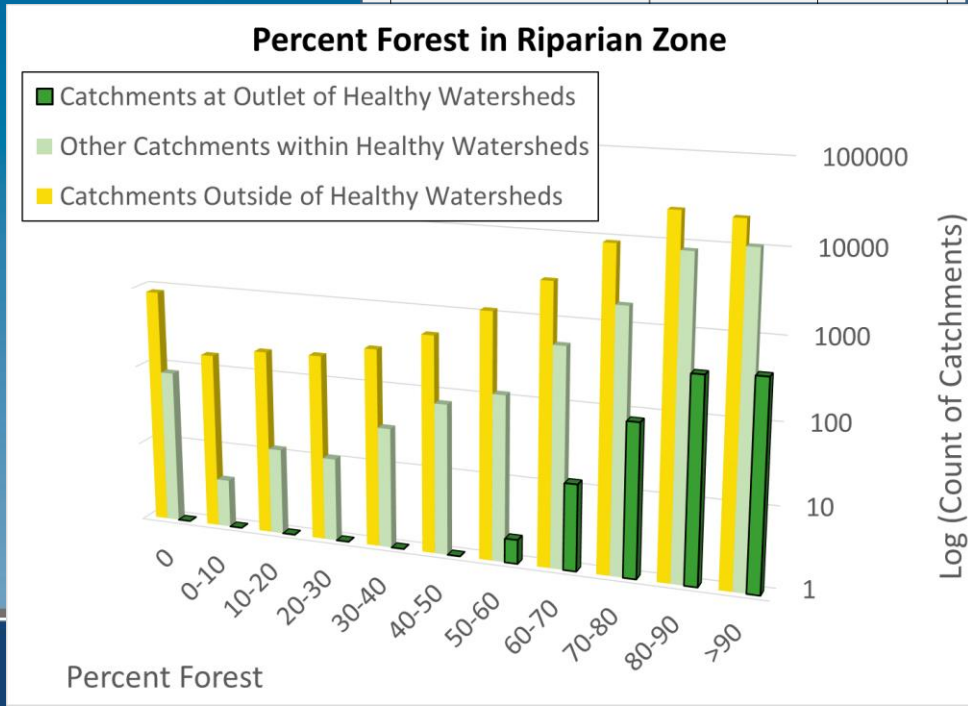
Metric Performance

- Example: Percent Forest in Riparian Zone
- Indicative of: Landscape condition
- Value calculated for entire upstream riparian zone
- Metric expected to be high in healthy watersheds

Findings:

- As expected, values for percent riparian forest are high in the Chesapeake Bay (CB) Healthy Watersheds, all with >50% forest in riparian zone



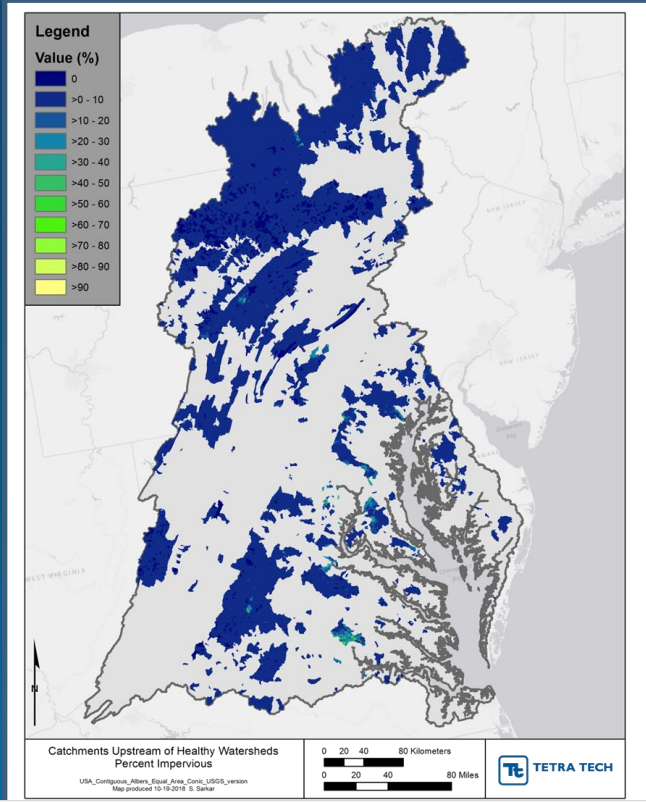


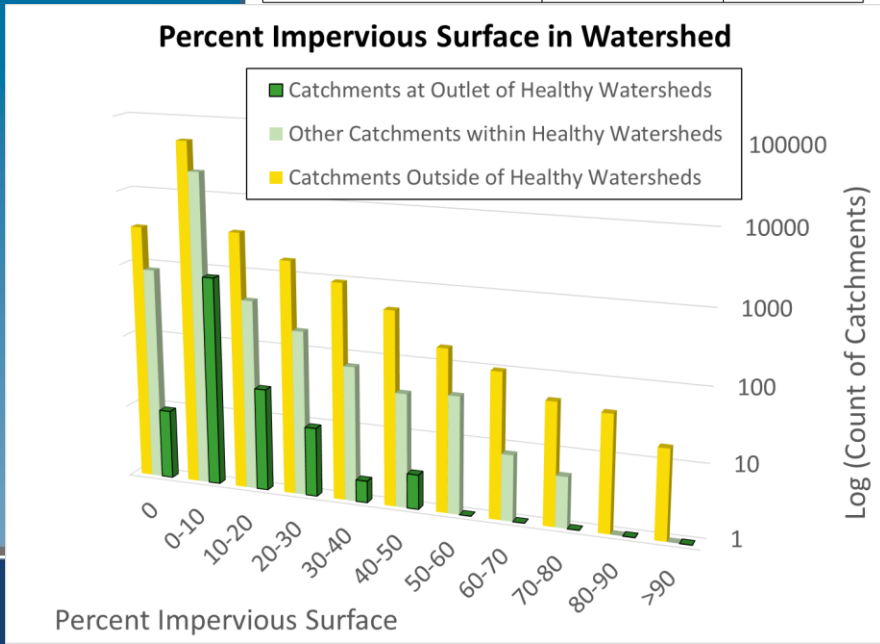
Metric Performance

- Example: Percent Impervious Surface Cover in Watershed
- Indicative of: Hydrologic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

- Impervious cover is generally low in CB Healthy Watersheds, many with <10% or <20% impervious cover
- Some with 20-50% impervious cover, levels that may lead to degradation



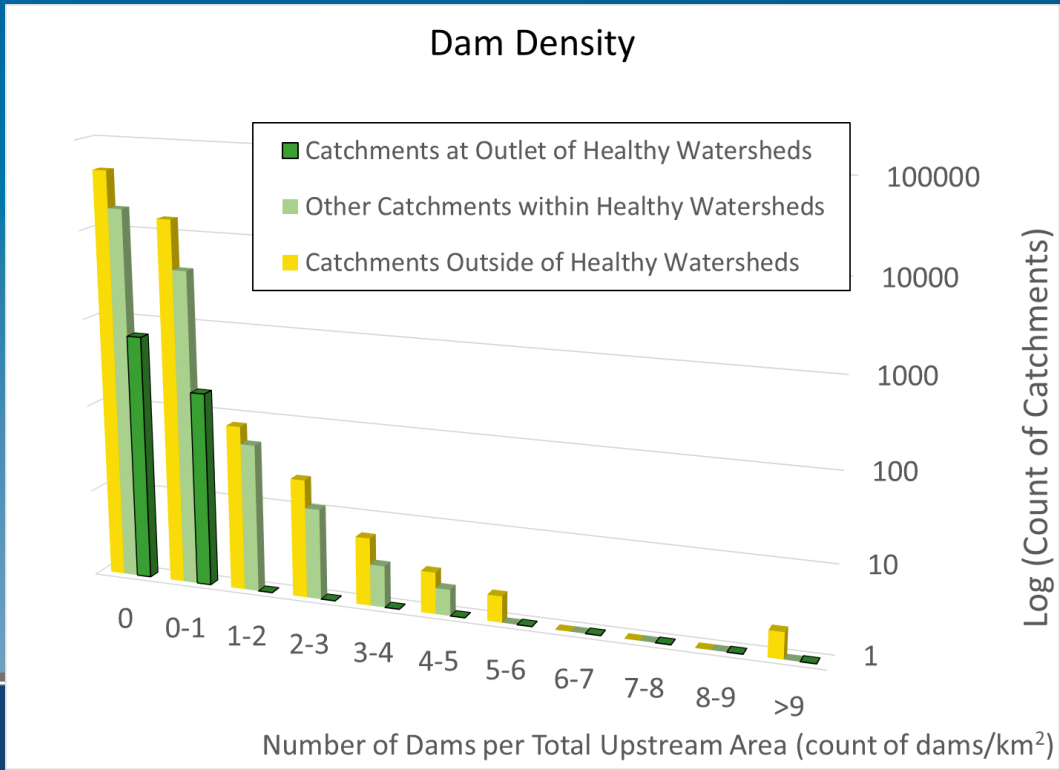


Metric Performance

- Example: Dam Density in Watershed
- Indicative of: Geomorphic condition
- Value calculated for entire upstream watershed area
- Metric expected to be low in healthy watersheds

Findings:

- Dam density low in CB Healthy Watersheds; 0 to 1 dam per km^2
- Many zero values

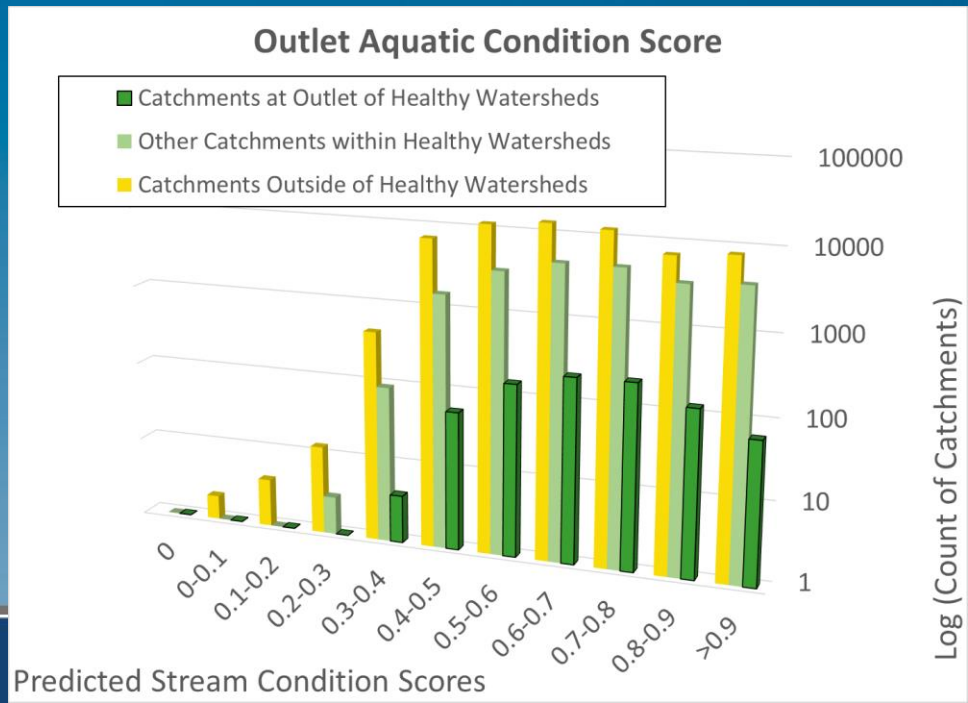


Metric Performance

- Example: Aquatic Condition Score
- Indicative of: Biological condition
- Value calculated for catchment at healthy watershed outlet only
- Metric expected to be high in healthy watersheds

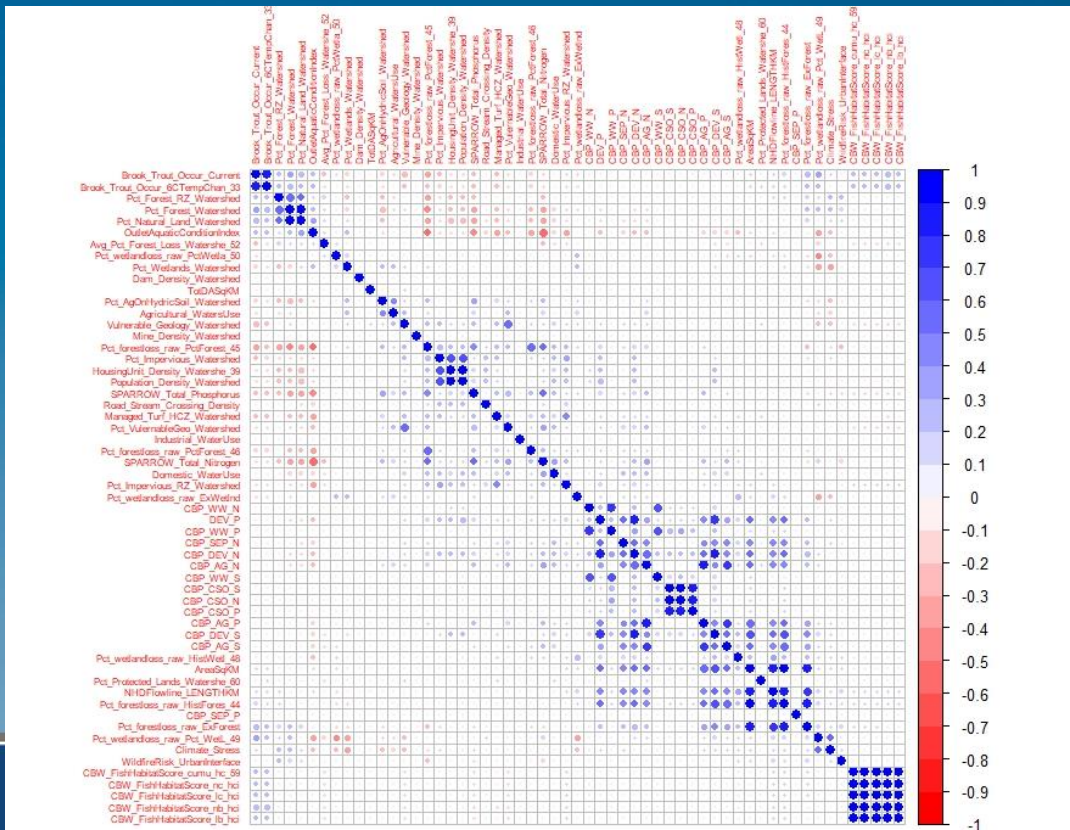
Findings:

- Aquatic condition scores tend to be higher in CB Healthy Watersheds
- Current indicator provides estimates across all watersheds using national model



Developing an Overall Index of Watershed Health

- Assessed correlations among watershed condition metrics
- PHWA employed simple additive approach to build six subindices and one overall index
- Also testing random forest / stepwise regression approach to build index based on individual watershed condition metrics



```
Call:
glm(formula = ExistingHW ~ ., family = binomial, data = fishy)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9625  -0.7985  -0.6189   0.8986   3.6844

Coefficients:
                                Estimate Std. Error z value Pr(>|z|)
(Intercept)                    -2.361567   0.087448 -27.005  < 2e-16 ***
Pct_Forest_Watershed            2.847948   0.139195  20.460  < 2e-16 ***
Pct_Forest_RZ_Watershed         0.594413   0.085540   6.949 3.68e-12 ***
Pct_Impervious_Watershed       -4.232838   0.202585 -20.894  < 2e-16 ***
Pct_Impervious_RZ_Watershed    -0.506342   0.067466  -7.505 6.14e-14 ***
Pct_AgOnHydricSoil_Watershed   -4.499293   0.288726 -15.583  < 2e-16 ***
Pct_VulernableGeo_Watershed     0.119759   0.028768   4.163 3.14e-05 ***
SPARROW_Total_Phosphorus        1.003068   0.264111   3.798 0.000146 ***
Pct_Wetland_Remaining          -0.371099   0.036634 -10.130  < 2e-16 ***
HabitatConditionIndex_LC        0.404602   0.006549  61.777  < 2e-16 ***
Outlet_Aquatic_ConditionInde_52 1.074884   0.067844  15.843  < 2e-16 ***
Pct_Natural_Land_Watershed     -2.123635   0.134579 -15.780  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 97589  on 83622  degrees of freedom
Residual deviance: 87827  on 83611  degrees of freedom
AIC: 87851

Number of Fisher Scoring iterations: 5
```

Metric Contributions

Future Tracking of Watershed Health

- **Certain metrics able to be updated readily with new data**
  - Example: Land use/land cover metrics – future versions of Chesapeake Bay high-resolution data
  - Example: Metrics derived from StreamCat and EnviroAtlas – periodic updates of EPA datasets
- **New metrics under development**
  - Fish Habitat: new CBP regional fish habitat assessment under development
  - Biological condition: CBP freshwater benthic index ("Chessie BIBI"), with hybrid monitoring/modeling approach to develop baseline condition and periodic assessments to track stream health

2019…2025…2030…2040…2050…

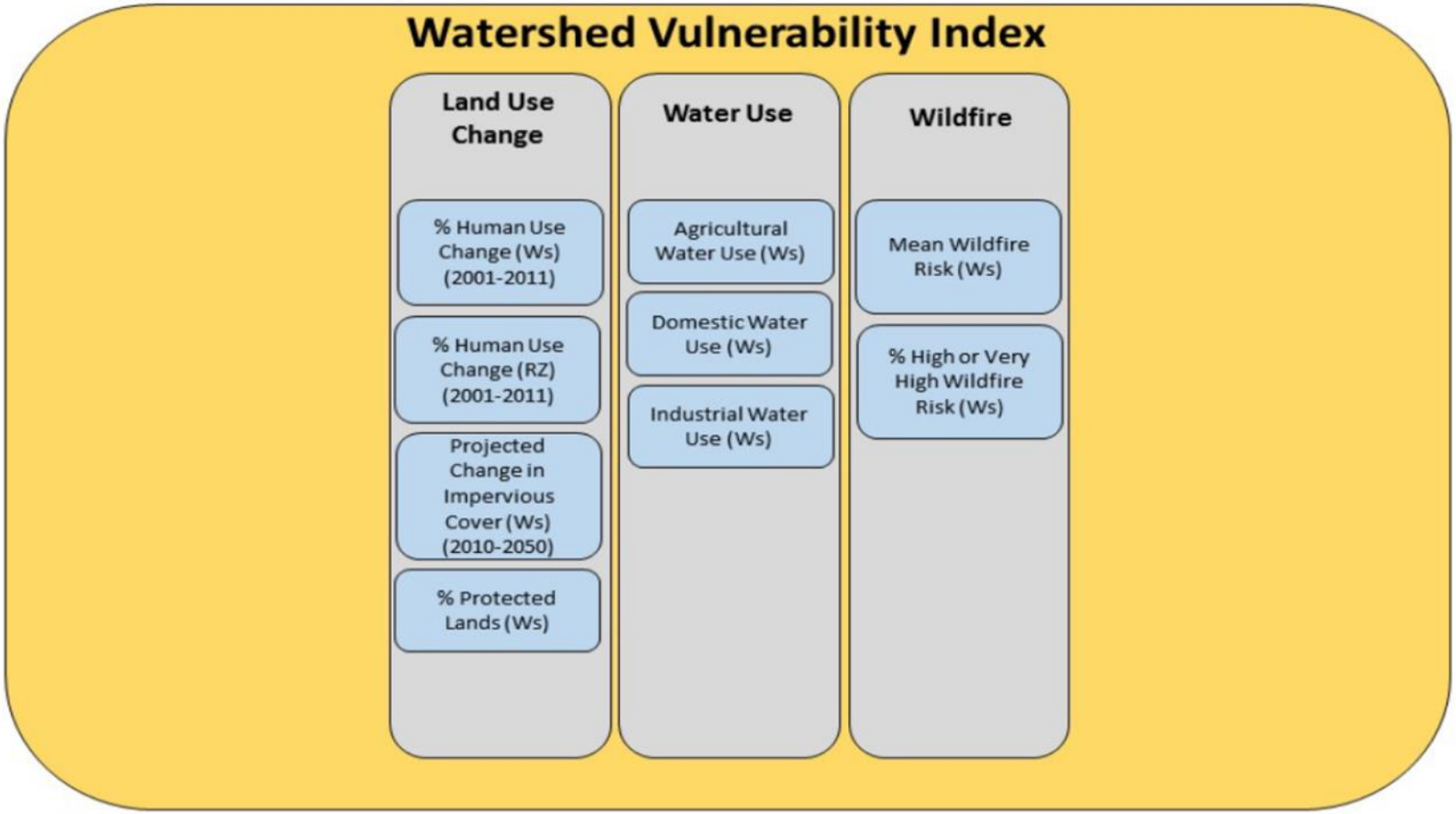
Today's Presentation

- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

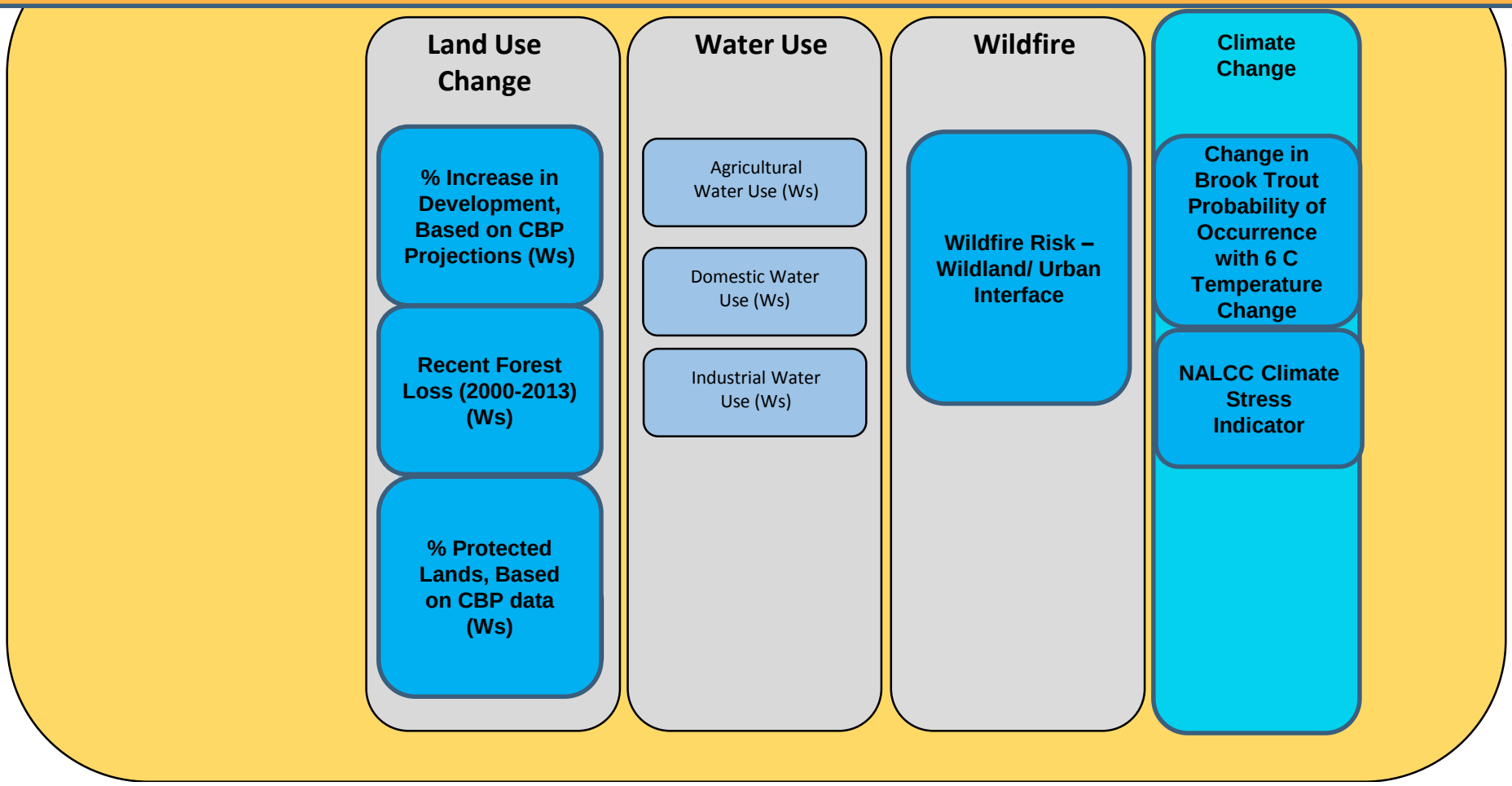
Indicators of Watershed Vulnerability

- **Important to consider stressors that affect healthy watersheds or result in future degradation, such as:**
  - Future development
  - Forest loss
  - Extent of land protection
  - Water use
  - Wildfire risk
  - Climate change

PHWA Metrics – Watershed Vulnerability



Chesapeake Bay Watershed Vulnerability Indicators **DRAFT**



Original PHWA Metrics

New Metrics

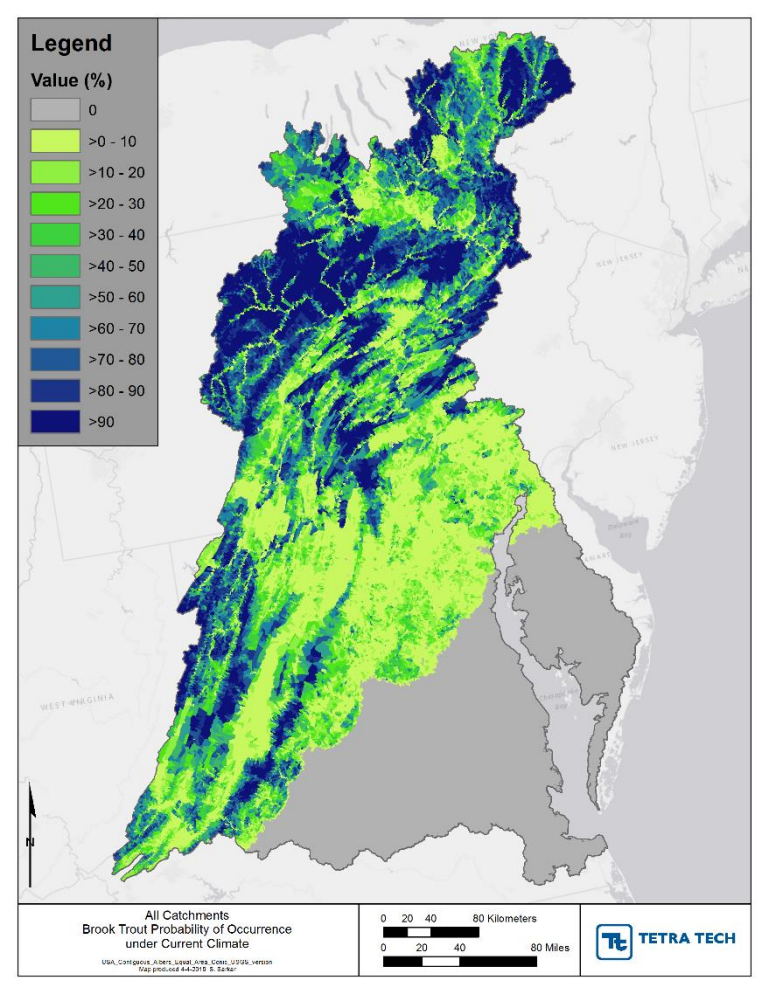
Note: All metrics calculated at NHDPlus catchment scale

Ws = Metric value calculated for entire upstream watershed

Vulnerability to Climate Change

- Example: Brook Trout Probability of Occurrence

Current climate condition

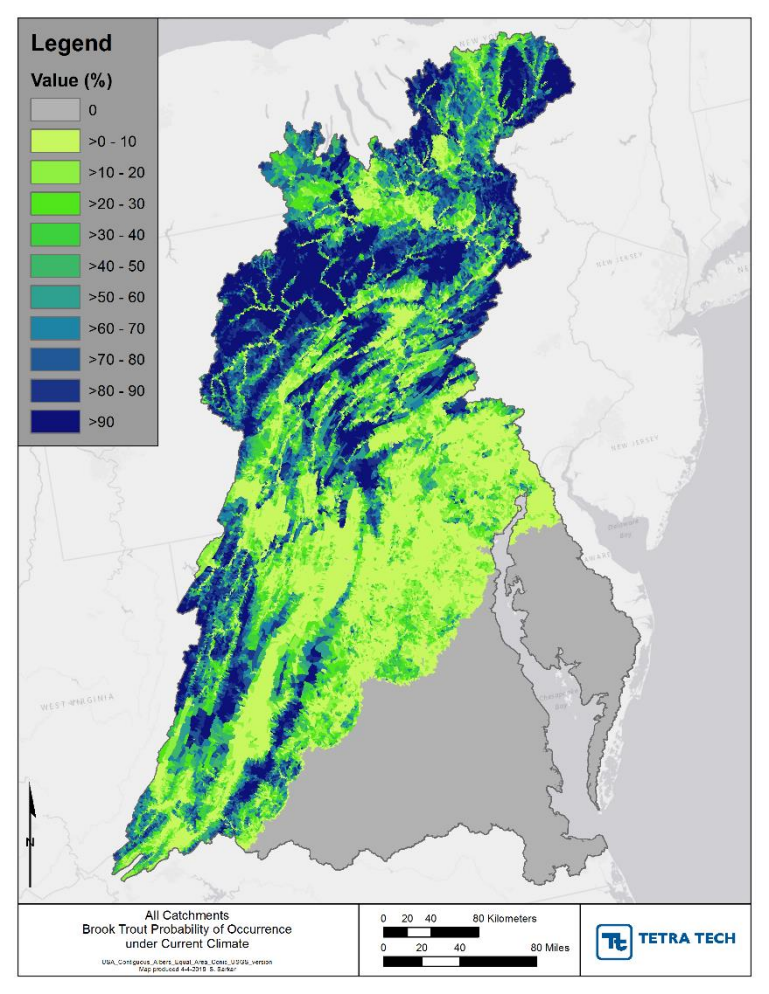


- Data source: Nature's Network, USGS Conte Lab
- Model included effects of landscape, land-use, and climate variables on the probability of brook trout occupancy in stream reaches
- Provides predictions under current environmental conditions and future increases in stream temperature.

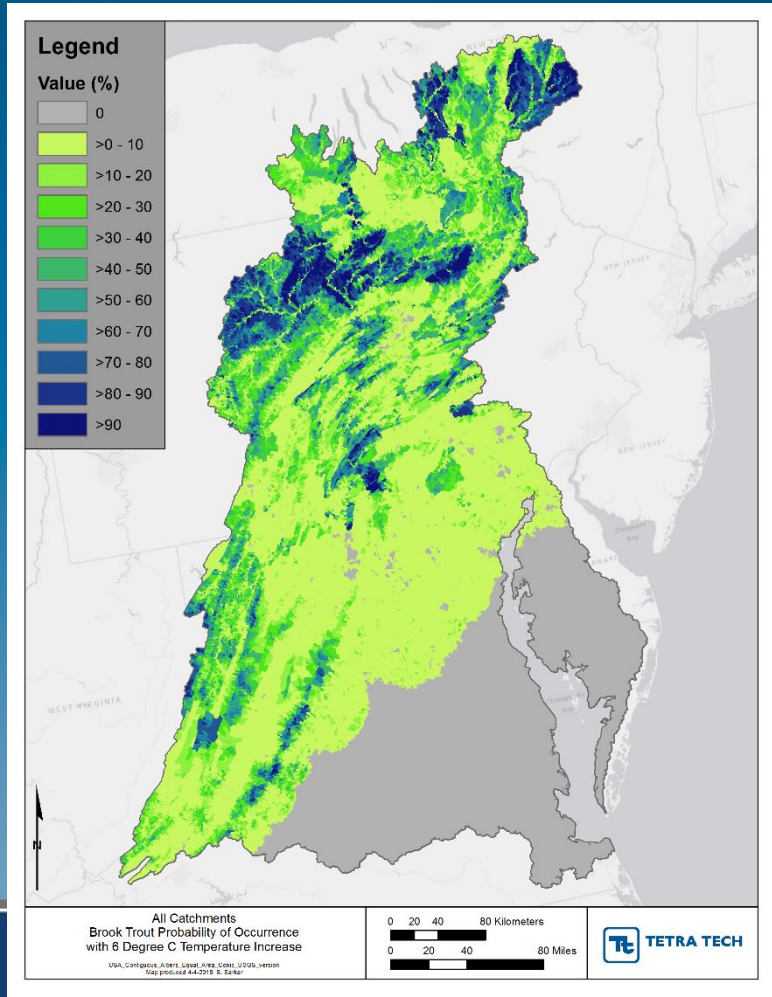
Vulnerability to Climate Change

- Example: Brook Trout Probability of Occurrence

Current climate condition



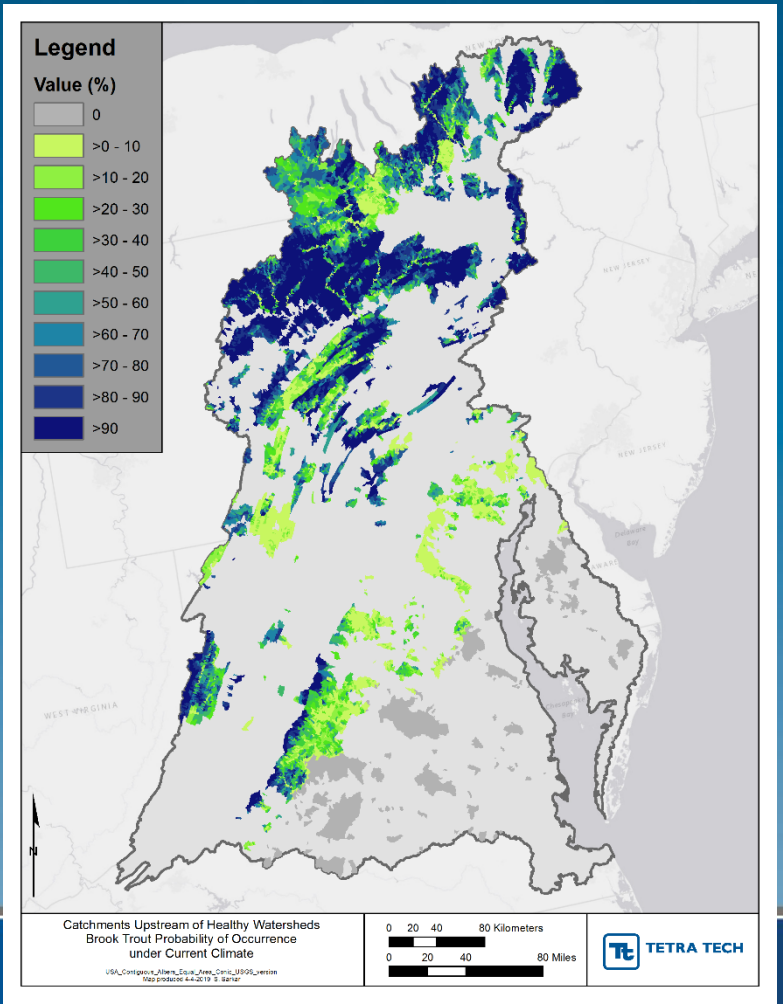
With 6 degree C increase



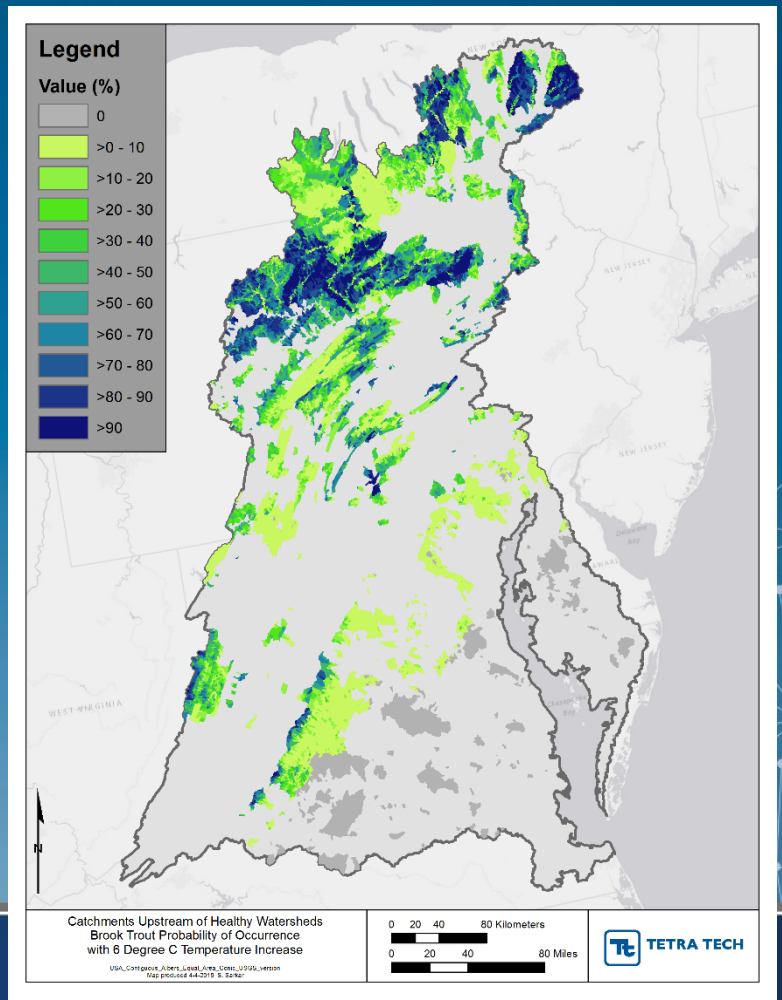
Vulnerability to Climate Change

- Example: Brook Trout Probability of Occurrence

Current climate condition



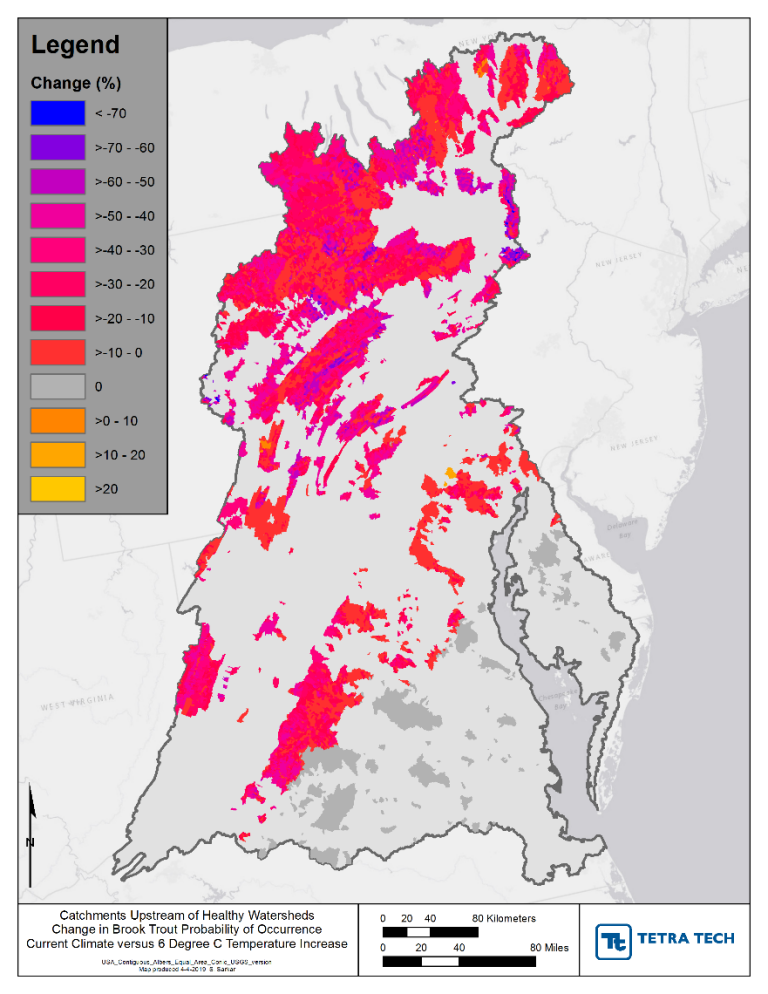
With 6 degree C increase



Vulnerability to Climate Change

- Example Metric: Change in Brook Trout Probability of Occurrence

In Healthy Watersheds

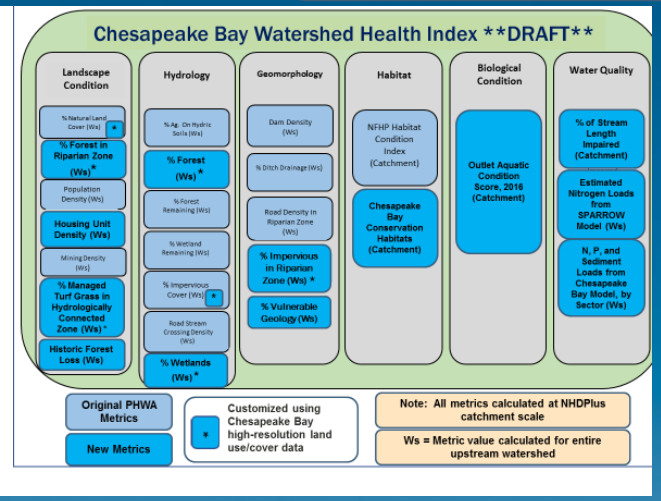


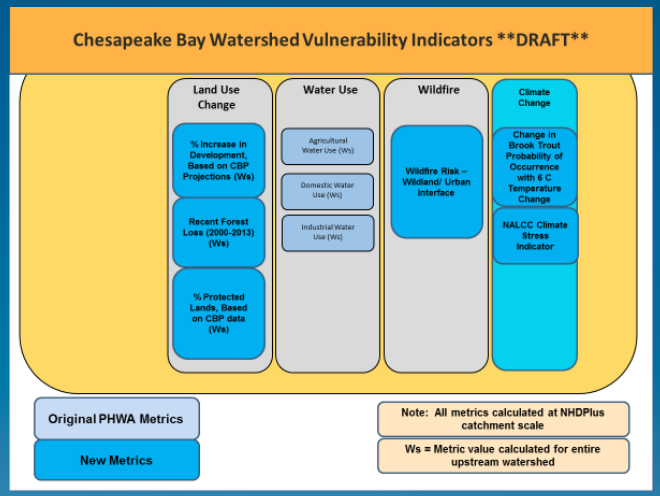
Today's Presentation

- Adapting the PHWA approach and addressing scale
- Indicators of watershed condition
- Indicators of watershed vulnerability
- Data visualization and access to data

Data Visualization and Access Tools

Watershed Health and Vulnerability Metrics





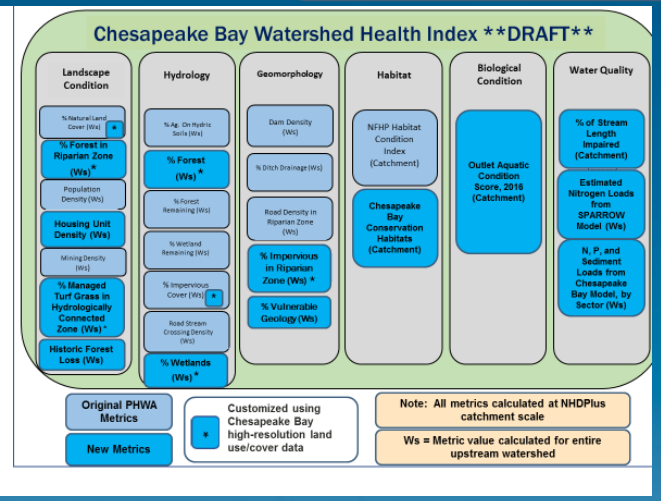
Combine Metrics for Tracking Watershed Health

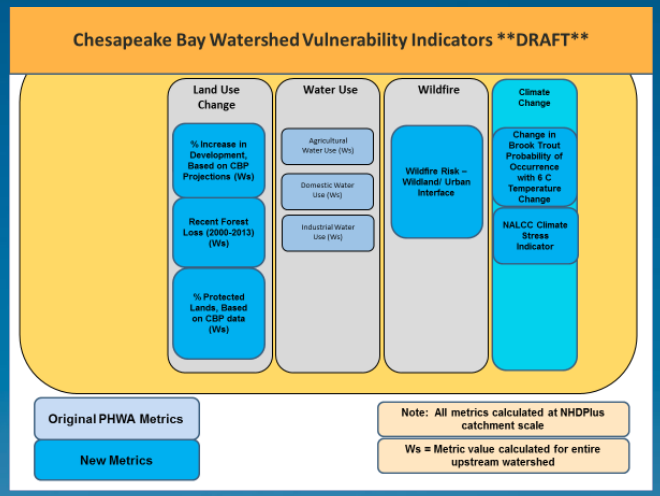
Identify Vulnerabilities

Geodatabase with suite of data, basic approach for analysis and visualization

Data Visualization and Access Tools

Watershed Health and Vulnerability Metrics





Combine Metrics for Tracking Watershed Health

Identify Vulnerabilities

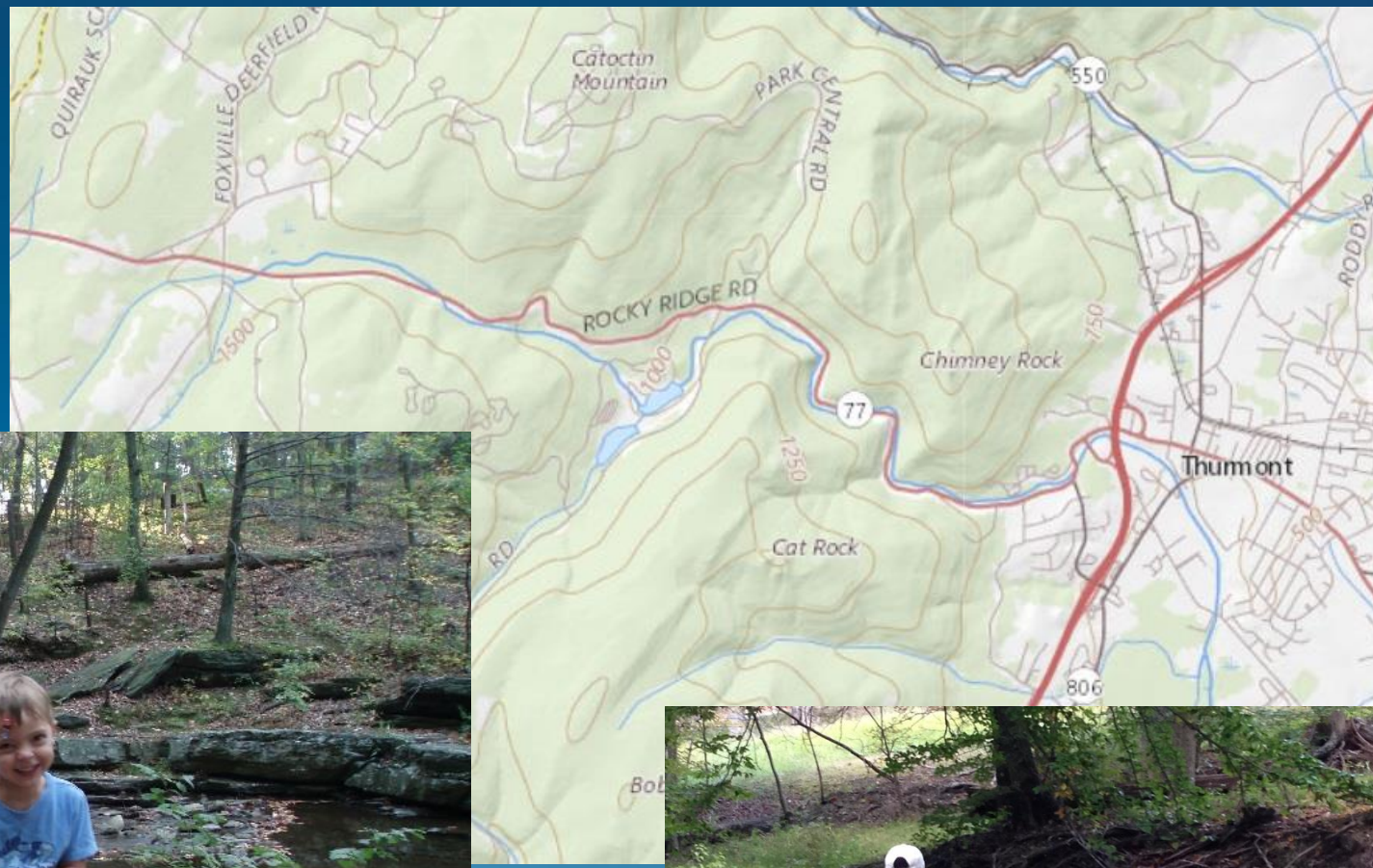
Geodatabase with suite of data, basic approach for analysis and visualization

Advanced Tools for Analysis and Visualization

Online Data Access

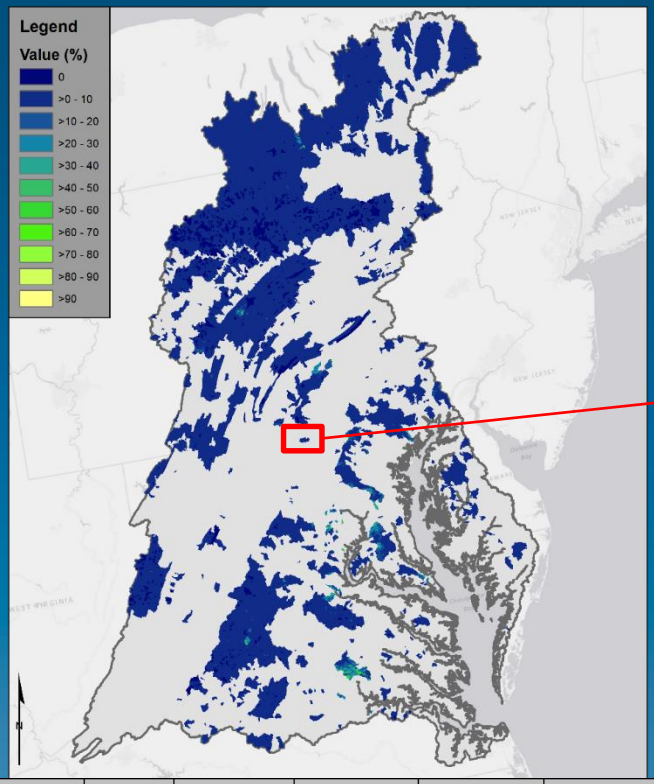
- Provide suite of Healthy Watershed metrics and indicators for data visualization and analysis
- Geodatabase structured by catchment (COMID)
- Ability to select areas of interest, compare values, visualize data…and more
- Accessible via ArcGIS Online or CBP Chesapeake Open Data portal

Example: Big Hunting Creek near Thurmont, MD

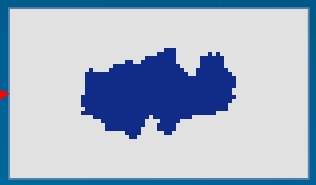


Example: Percent Impervious Cover

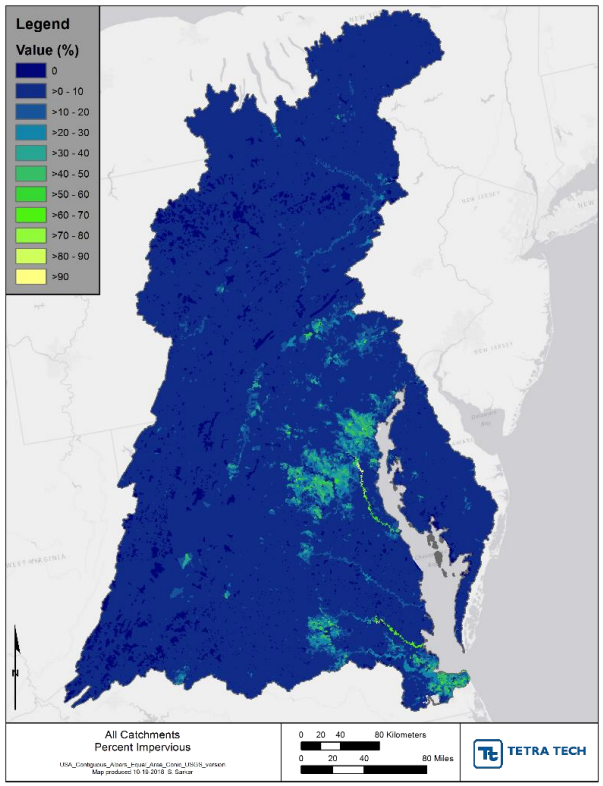
Healthy Watersheds



Big Hunting Creek



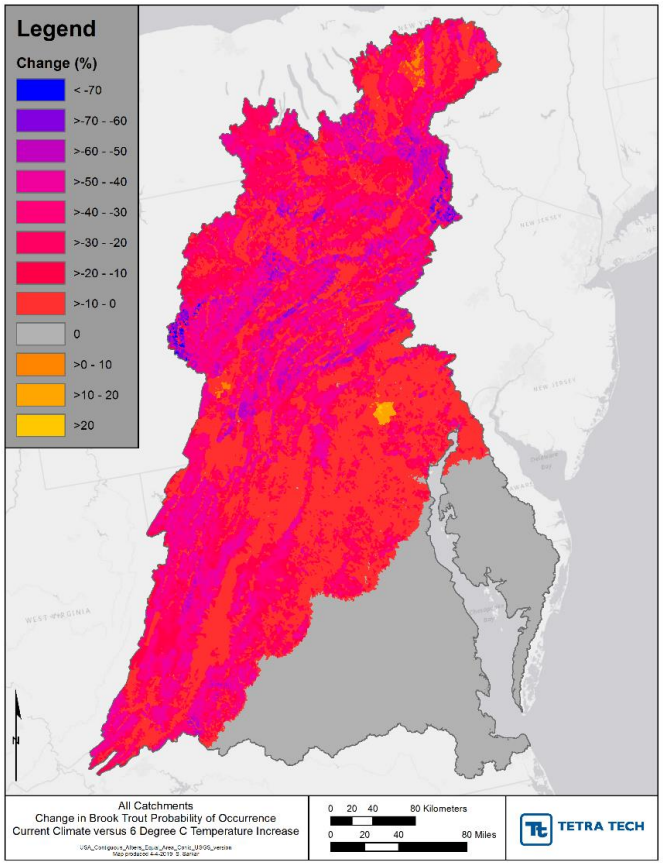
All Catchments



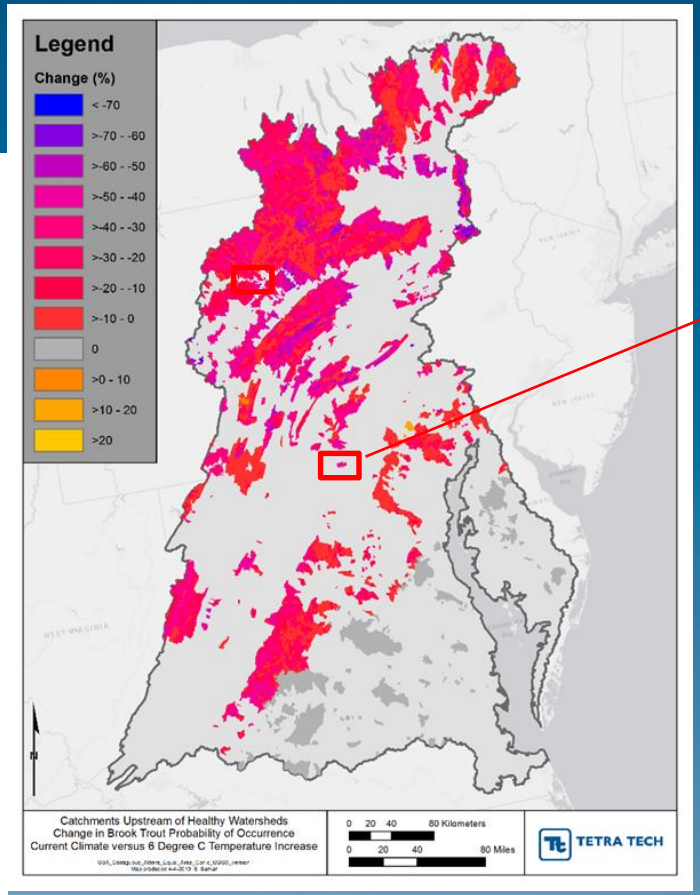
OBJECTID	COMID	Total Upstream Drainage Area (sq km)	Aquatic Condition Index	Road Density (Cs)	Road Density (Ws)	Road/Stream Crossings (Ws)	Housing Unit Density 2010 (Ws)	Population Density 2010 (Ws)	Impervious (Cs)	Impervious (Ws)
45150	8448584	29.5938	0.6538	5.3470	3.5362	0.4731	0.0041	0.0045	0.0891	0.0111
45136	8448556	10.4337	0.7589	3.2747	2.8520	0.4792	0.0011	0.0012	0.0280	0.0141
45139	8448562	6.9849	0.8106	4.5346	1.7741	0.2863	0.0011	0.0012	0.0023	0.0235
45149	8448582	6.3117	0.8198	1.5082	1.5082	0.3169	0.0011	0.0012	0.0220	0.0220
45388	8449076	1.4373	0.6660	2.2839	2.2839	0.6957	0.0011	0.0012	0.0415	0.0415
45389	8449078	2.6784	0.7116	2.6806	2.6806	0.7467	0.0011	0.0012	0.0326	0.0326
45419	8449144	17.7921	0.8604	2.3465	2.4658	0.3934	0.0011	0.0012	0.0108	0.0182
45420	8449146	10.4481	0.8853	4.5346	2.8538	0.4786	0.0011	0.0012	0.0118	0.0310
45421	8449150	6.9516	0.7945	4.1690	1.7659	0.2877	0.0011	0.0012	0.0391	0.0036

Example: Change in Brook Trout Probability of Occurrence

All Catchments



Healthy Watersheds



Big Hunting Creek

Demonstration

Management Applications

- Chesapeake Bay Program - assess/track conditions, support management strategies
- State agencies / healthy watershed program managers: track conditions in Tier II waters, identify and evaluate potential threats, adapt management strategies
- Data readily available through CBP online platform for variety of users and uses including local governments and watershed groups
- Flexible framework that can be updated periodically, augmented with new or more specific local data
- Potential to screen watersheds to identify healthy ecosystems not currently protected

Seeking Your Feedback

- How will you be able to use these data?
- How best to provide data for a variety of users?
- What should be added/updated in future?

Acknowledgements

- Chesapeake Bay Program
- EPA Healthy Watersheds Program
- Jurisdictional watershed managers and data contacts – NY, PA, WV, VA, DC, MD, DE
- Peter Cada, formerly Tetra Tech
- Chesapeake Bay Trust